

PRESENTATION FOR INDIANA VW MITIGATION



ELECTRIC VEHICLE 101



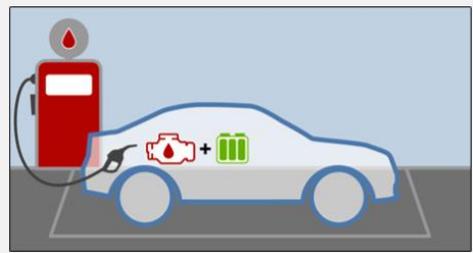
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Argonne National Laboratory

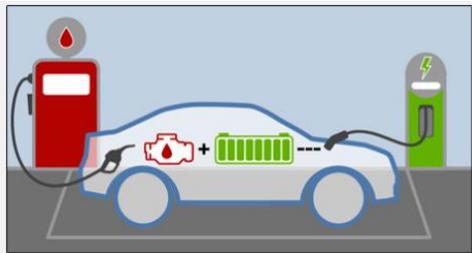
October 8, 2019
Indianapolis, IN

WHAT ARE PLUG-IN ELECTRIC VEHICLES

Hybrid Electric Vehicle



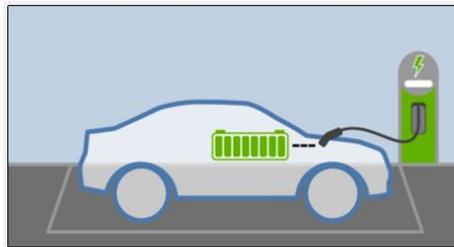
Plug-in Hybrid Electric Vehicle



Battery Electric Vehicle (BEV): all-electric car only powered by batteries

Plug-in Hybrid Electric Vehicle (PHEV) or Extended Range Electric Vehicle (EREV): vehicle that can be powered by either batteries, a gasoline engine, or both

Battery Electric Vehicle



ARGONNE HAS BEEN TRACKING E-DRIVE VEHICLE SALES SINCE FIRST HEV

Monthly summary of E-drive market status: HEV, PEV, and FCEV

CAREERS NEWS EVENTS STAFF DIRECTORY

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RESEARCH BUSINESS COMMUNITY ABOUT US



ENERGY SYSTEMS DIVISION

Light Duty Electric Drive Vehicles Monthly Sales Updates

Monthly sales data for electric vehicles

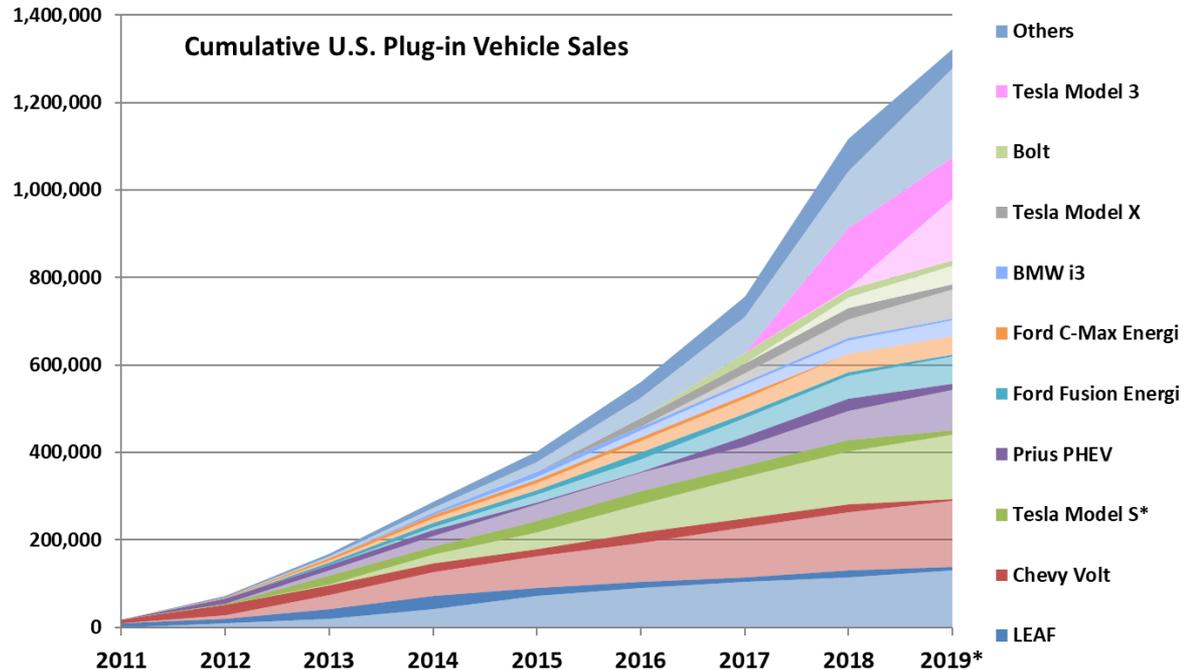
ES Division

About ES >

<https://www.anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates>

OVER 1.3 MILLION PEVS SOLD IN THE UNITED STATES, CUMULATIVELY

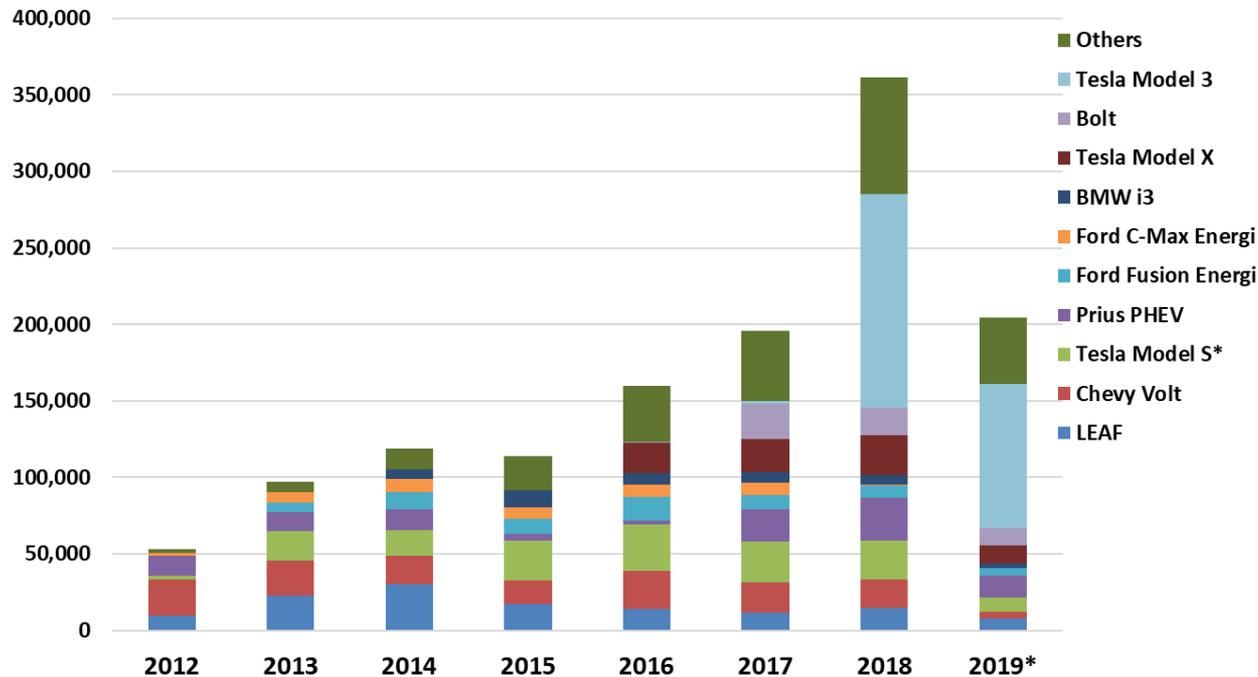
1 million milestone reached in October, 2018



- Top 10 selling models account for >80% of overall sales
- >30 models are actively selling on the market

ANNUAL PEV SALES INCREASED >80% IN 2018

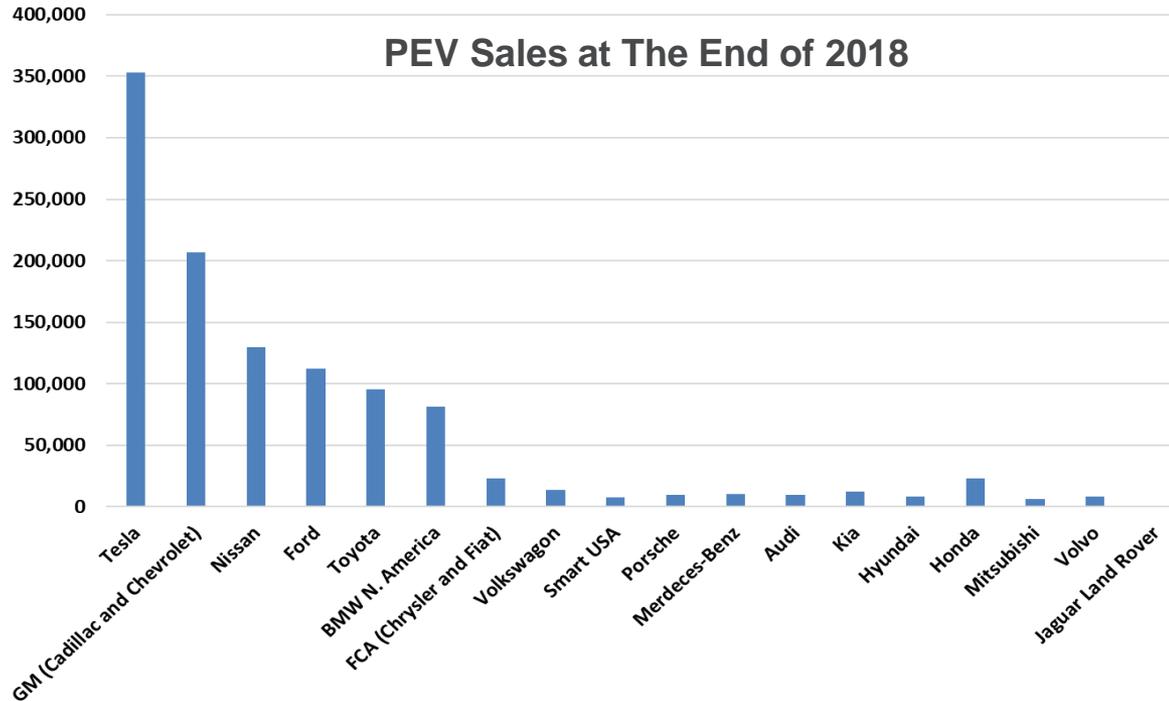
Increase due Tesla Model 3 sales and more model availability



- Tesla Model 3 sold almost 140,000 units in 2018
- 15+ new models were introduced between 2017-2018

TESLA AND GM SOLD 200K QUALIFYING VEHICLES - FEDERAL TAX CREDIT

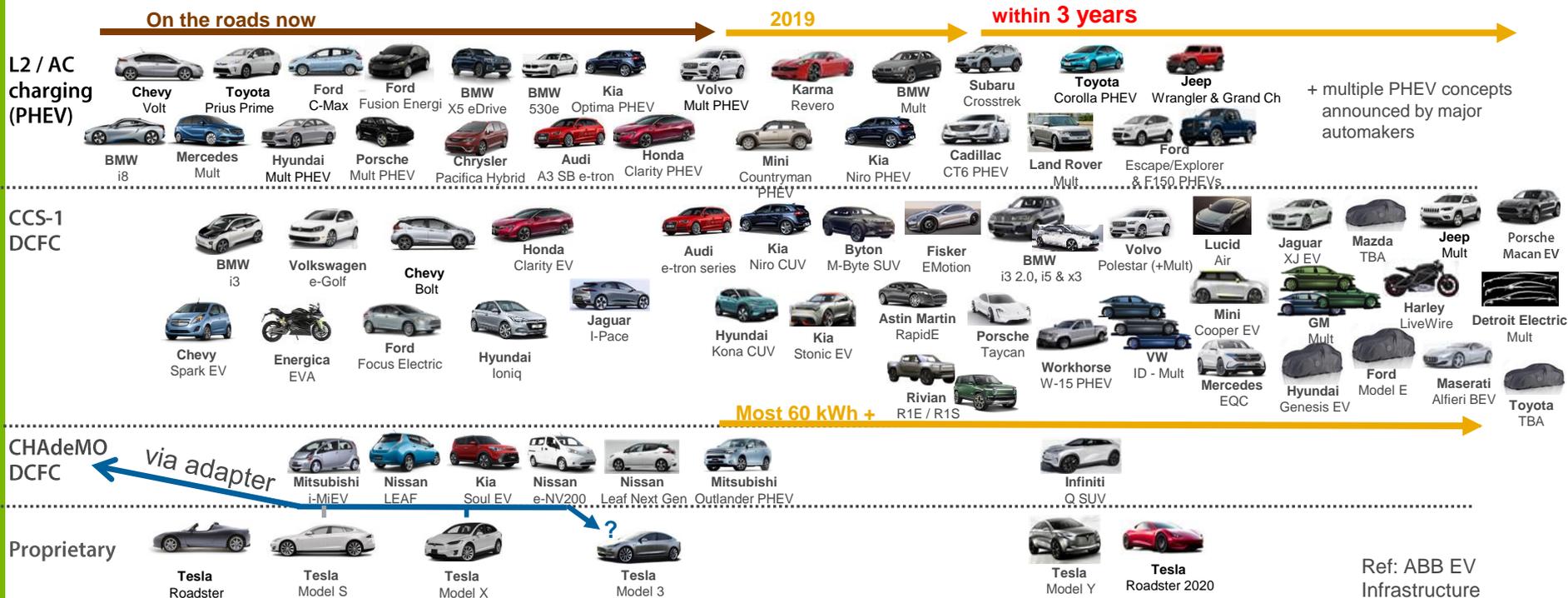
Credit phase-out period began January 1st, 2019 for Tesla



- Tesla was the first automaker to reach the threshold and trigger the phase-out period
- GM reached the threshold in December 2018 – phase-out begins April 2019
- Currently, each Tesla is qualified for \$1875 tax credit

ELECTRIC VEHICLES AND CHARGING

Passenger vehicles for North American market



IHS Markit: 70 plug-in models by 2020, 258 by 2025

OEMs HAVE COMMITTED TO OFFERING ELECTRIC PICKUPS IN THE NEAR FUTURE

Rivian, Tesla, Atlys, Bollinger... and many others



SEVERAL OEMS MADE ANNOUNCEMENT OF ELECTRIC MEDIUM- AND HEAVY-DUTY TRUCKS

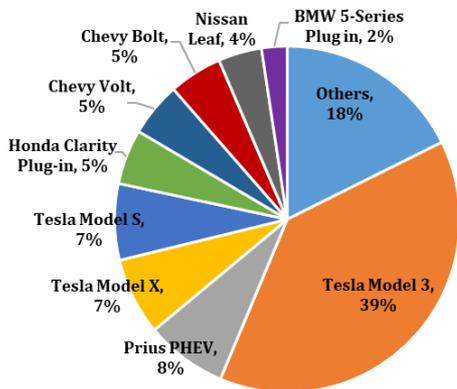
Some of the models could be used for inter-city freight

Manufacturer	Name	Capacity (lbs)	Energy Consumption* (kWh/mi)	Battery Pack (kWh)	Range (mi)	Base Price	Available
Tesla	Tesla Semi - 500	80,000	2.00	1000	500	\$ 150,000	2019
Tesla	Tesla Semi - 300	80,000	2.00	600	300	\$ 180,000	2019
Tesla	Tesla Founders Semi	80,000	2.00			\$ 200,000	2019
Daimler	E-FUSO Vision ONE	24,250	1.40	300	215		2021
Daimler	FUSO eCanter	3.5 tons	1.04	83	80		Available now
Cummins	AEOS	44,000	1.40	140	100		2022

* Full payload, highway driving speed (55mph)

Indiana EV Fact Sheet

2018 National Sales of Leading BEVs and PHEVs



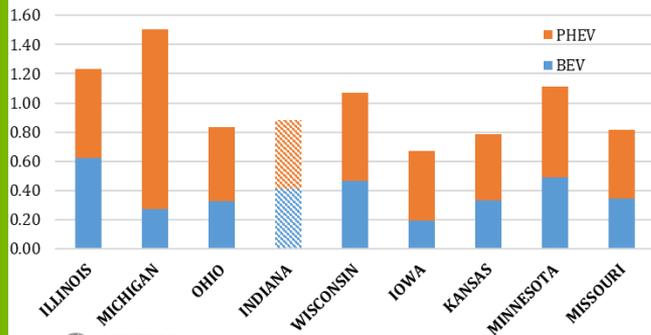
Avg. Price for Gallon of Gasoline in IN:

\$2.66

Avg. Price of Electric Equivalent Gallon in IN:

\$1.19

Midwest PEV Registrations per Capita (1000)

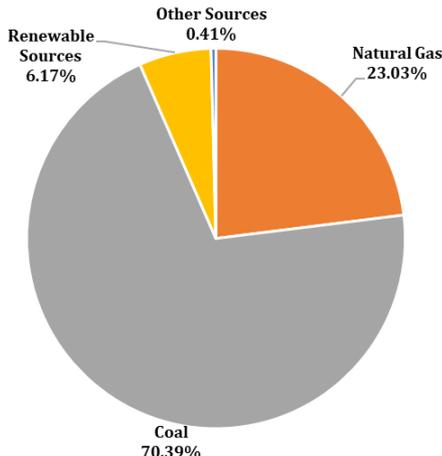


Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC.

* Indiana is based on available 2018 registration; All other states are based on available 2017 PEV registrations

Indiana EV Fact Sheet

2019 IN Electricity Generation Source



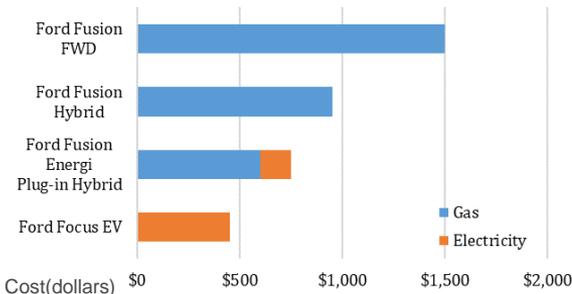
*Renewables (Wind, Solar, Biomass, and Hydro) make up 6.17% of Indiana's source for electricity.

~Other Sources includes Oil and Other Miscellaneous Sources

https://www.afdc.energy.gov/vehicles/electric_emissions.php

(Accessed August 2019)

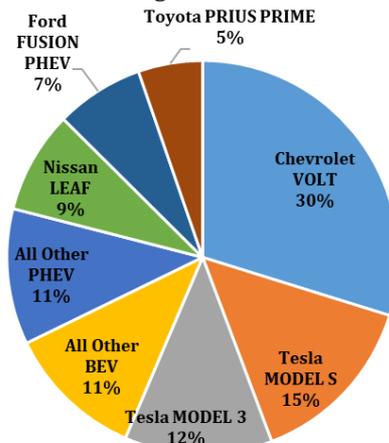
Annual Fuel Cost*



*based on 15,000 miles/year, IN averages of gasoline price of \$2.66/gallon and \$0.10/kWh of electricity

Indiana EV Fact Sheet

Indiana Leading PEV 2018 Registrations



Check model availability on AFDC. Note availability varies by state.

<https://www.afdc.energy.gov/states/>

IN Share of Total U.S. PEVs*

0.82%

* Available data: total U.S. 2017 PEV registrations

Reference:

Gasoline and Electricity Price, EIA
 Number of chargers by type, AFDC
 Vehicle fuel efficiency, Fueleconomy.gov
 Registration, IHS Polk Data
 PEV Sales, Hybridcars.com



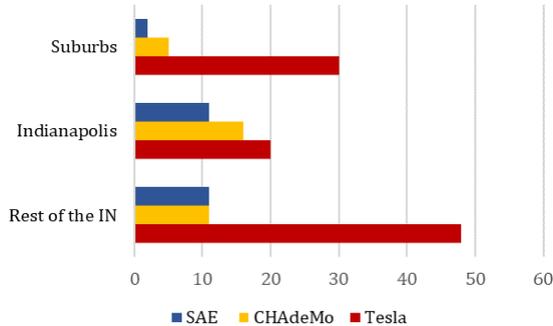
Indiana Electric Vehicles Fact Sheet

Charging Your Electric Vehicle:

There are three different levels of charging:

- **AC Level 1:** This provides 120 volts of charging, typically found in a home outlet. Overnight charging can replenish an entire PHEV battery, but not all BEV batteries.
- **AC Level 2:** This level provides 240 volts, about 10-20 miles of range per hour of charging. This can be installed for home charging, but is also used for public charging. In the home, it can replenish an entire BEV battery overnight.
- **DC Fast Charging:** This is for rapid charging along heavy traffic corridors. In 20 minutes it can provide enough battery life for a 50-70 miles of range. In ideal conditions of mild temperatures and a low initial charge, a fast charge to 80% will take about 30 minutes for a BEV, but longer in cold weather. There are three types of DC fast charging systems, depending on the vehicle: SAE J1772 combo, CHAdeMO, and Tesla. Adapter is available for Tesla Model S and Model X to use the CHAdeMO chargers.

DC Fast Chargers in IN

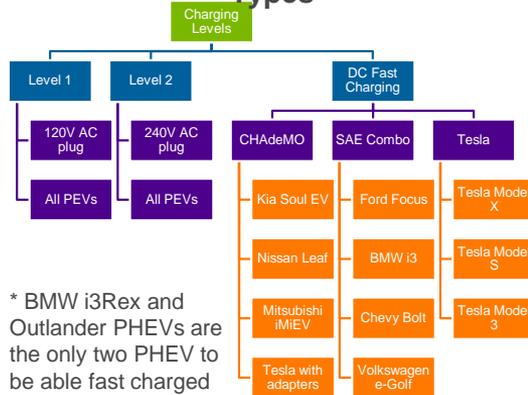


Note: A station with both CHAdeMO and SAE availability is assumed to have half CHAdeMO and half SAE (if total # of chargers is an odd number, CHAdeMO is assumed to be one more than SAE)



Updated August 16, 2019

Charging Levels and Types



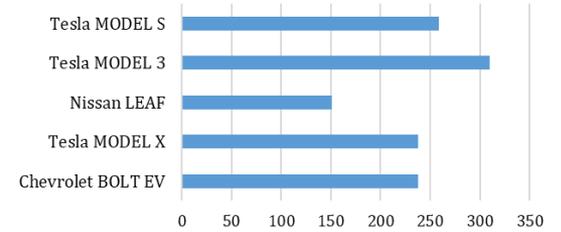
* BMW i3Rex and Outlander PHEVs are the only two PHEV to be able fast charged

Did You Know?

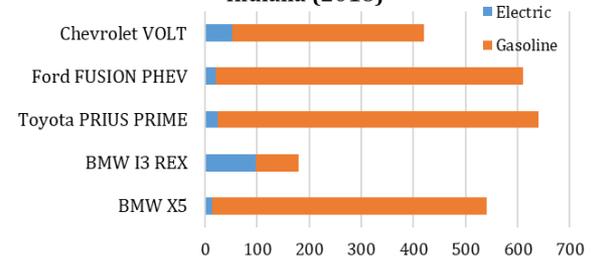
A full charge can give PHEVs up to 100 miles of electric range and BEVs up to 300 miles of range, depending on the model. These distances can change depending on factors like weather, driving conditions, and driving habits. See on the right how varying your speed, driving behavior, and temperature affect battery range.

*based on averages of 3 2015 BEVs tested by ANL and rated on fueleconomy.gov (Mercedes-Benz-B-Class EV, Kia Soul EV, Chevrolet Spark EV)

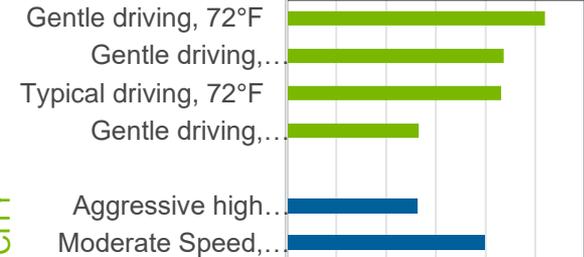
EPA Rated Range of Top Selling BEV in Indiana (2018)



EPA Rated Range of Top Selling PHEV in Indiana (2018)



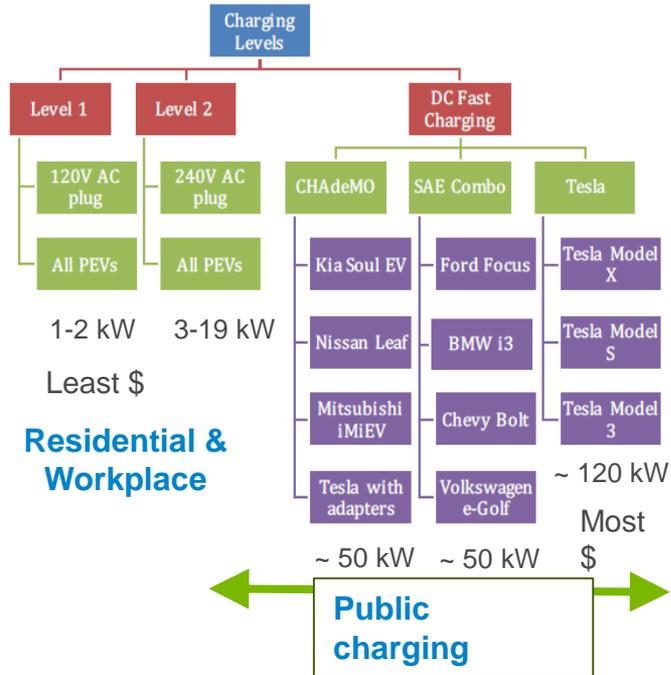
Range Depletion Dependent on Driving and Weather Conditions



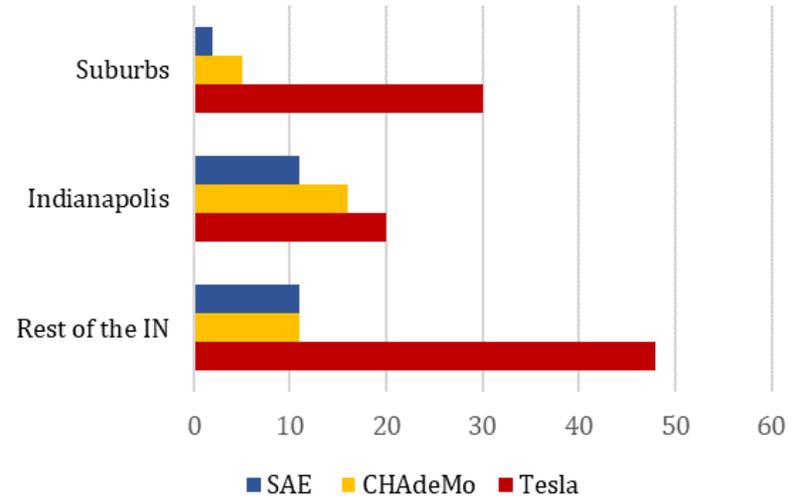
HIGHWAY CITY

0% 25% 50% 75% 100% 25% 50%
Percentage of rated electric range

LEVEL 1 & 2 CHARGING ARE AT RESIDENCES & WORKPLACES. THE PURPOSE OF TESLA'S HIGH POWER DC FAST CHARGING IS LONG DISTANCE TRAVEL. OTHER DCFC IS MORE URBAN & LOCAL.

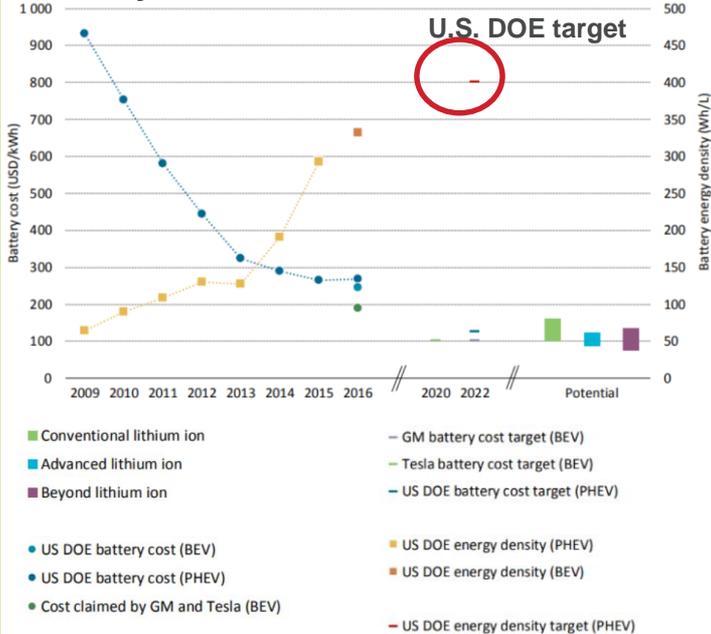


DC Fast Chargers in IN



BATTERY ADVANCES ARE MAKING BEVS AFFORDABLE

Evolution of Battery Energy Density and Cost



Vehicle cost per mile of battery range

Vehicle Model	Battery energy density (Wh/L)	0-60mph (sec)	Range (miles)	MSRP
2019 Tesla Model 3 Long Range	\$139	3.2-5.6	310	\$43,000
2019 Nissan Leaf (62kW-hr..)	\$146	6.5	226	\$32,893
2019 Hyundai Kona Electric	\$158	6.6	258	\$40,750
2019 Chevrolet Bolt EV	\$163	6.5	238	\$38,763
2018 Ford Focus Electric	\$253	9.9	115	\$29,120
2019 Hyundai Ioniq Electric	\$271	9.9	124	\$33,565
2019 Tesla Model S 100D	\$281	2.3-4.2	335	\$94,000
2019 Volkswagen e-Golf	\$283	9.6	125	\$35,395
2019 BMW i3	\$291	6.9-7.2	153	\$44,450
2019 BMW i3s	\$311	6.9-7.2	153	\$47,650
2019 Kia Soul Electric	\$315	9.7	111	\$34,950
2019 Tesla Model X 100D	\$329	2.8-9.7	295	\$97,000
2019 Jaguar I-Pace	\$333	4.5	234	\$77,938
2019 Fiat 500e	\$393	8.2	84	\$32,995
2019 Honda Clarity EV	\$411	8.8	89	\$36,620
2018 smart EQ fortwo (coupe)	\$435	11.4	58	\$25,243
2011 Nissan LEAF	\$443		74	\$32,780
2014 BMW i3	\$510		81	\$41,350
2012 Ford Focus Electric	\$516		76	\$39,200

Source: Global EV Outlook 2017

HOW MUCH CAN BE SAVED ON FUEL BY USING ELECTRICITY INSTEAD OF GASOLINE

“eGallon” depends on gas price, electricity price, fuel efficiency of the gasoline vehicle and comparable EV

eGallon: Compare the costs of **driving** with **electricity**

What is eGallon?
It is the cost of fueling a vehicle with electricity compared to a similar vehicle that runs on gasoline.

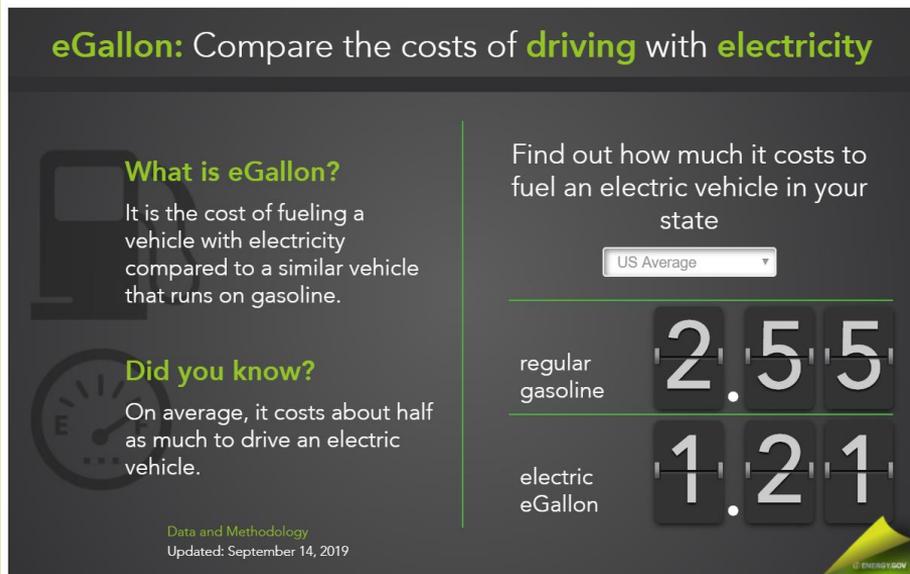
Did you know?
On average, it costs about half as much to drive an electric vehicle.

Data and Methodology
Updated: September 14, 2019

Find out how much it costs to fuel an electric vehicle in your state

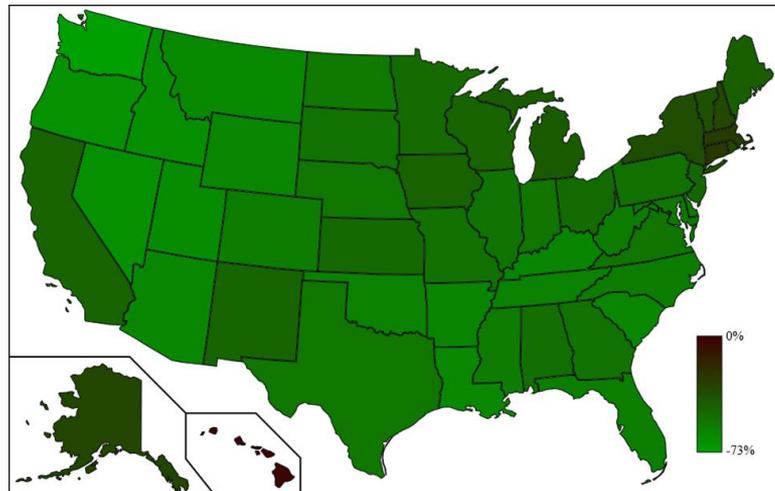
US Average

regular gasoline	2.55
electric eGallon	1.21



<https://www.energy.gov/articles/egallon-how-much-cheaper-it-drive-electricity>

Fuel cost savings for eGallon relative to gasoline



IN: \$2.58 vs. \$1.11, saving 57%

EVOLUTION: EDUCATION ON E-DRIVE VEHICLE

<https://evolution.es.anl.gov>



EVOLUTION
EDUCATION ON
E-DRIVE VEHICLES

Helps you calculate the benefits of owning an EV:

Get the facts about EVs and how they can fit:

- Your lifestyle,
- Your fuel price
- Driving patterns, and
- Charging needs

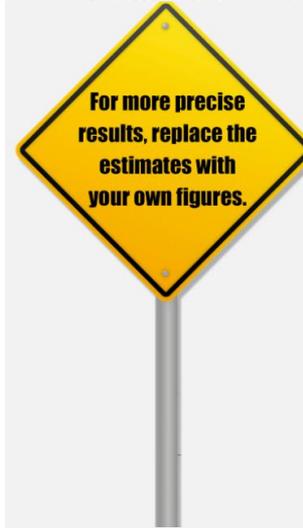
Fuel efficiency



Total cost of ownership



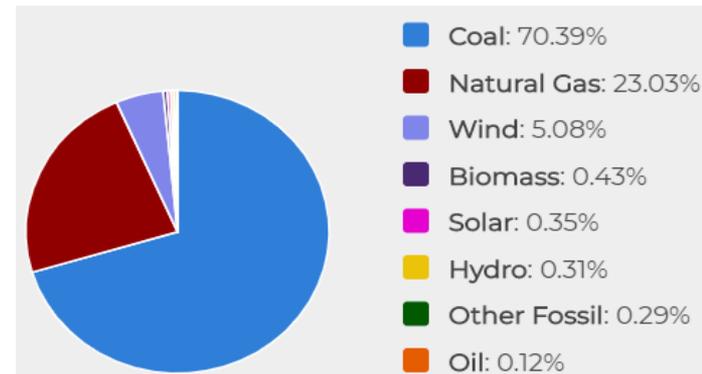
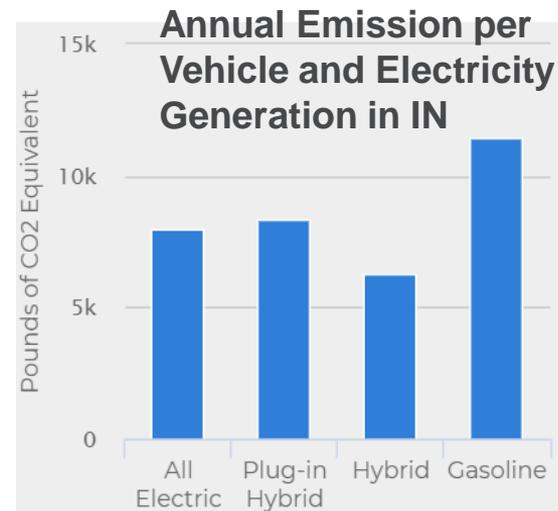
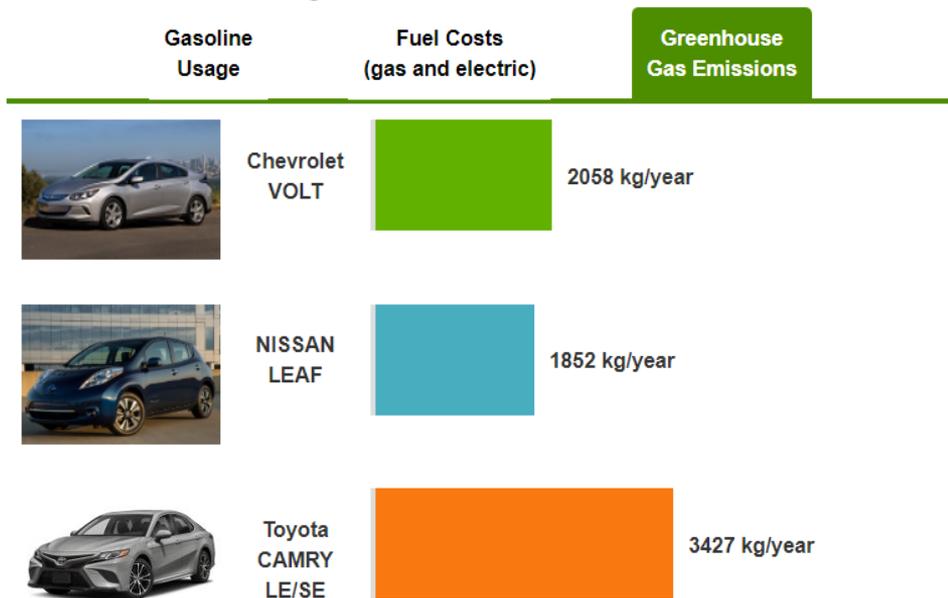
Environmental benefits



BEV AND PHEV HAVE LOWER ANNUAL EMISSIONS THAN NATIONAL AVERAGE DUE TO CLEANER ELECTRICITY GENERATION

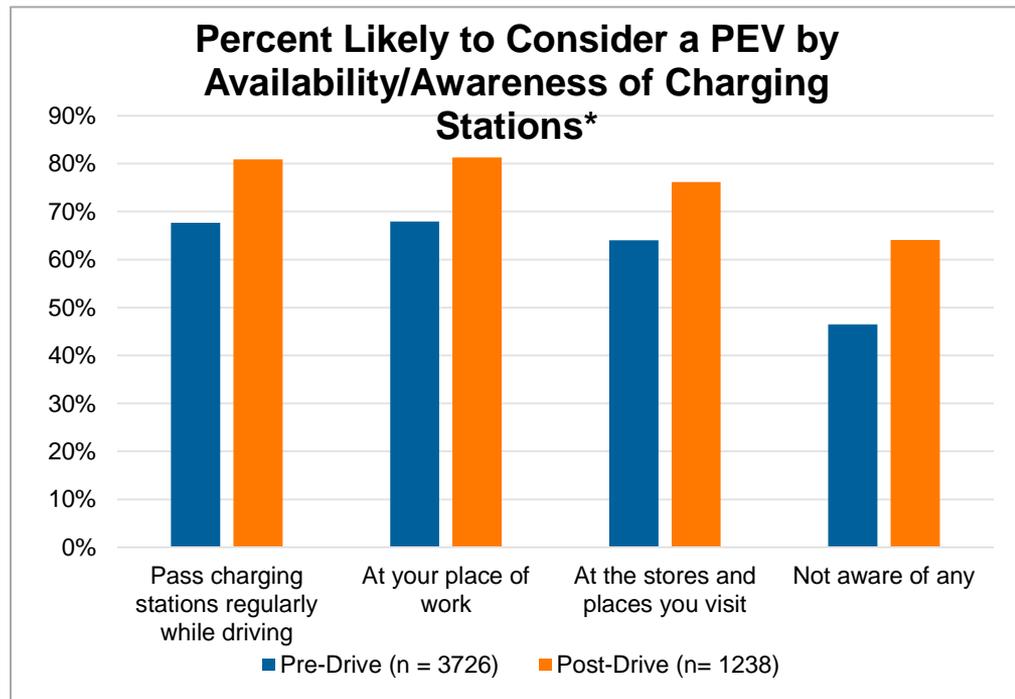
Comparison from Argonne's EVOLUTION tool

Evolution.es.anl.gov



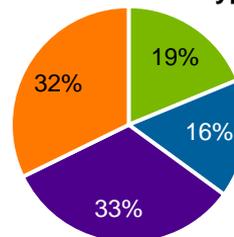
THOSE WITHOUT ACCESS TO LOCAL CHARGING STATIONS HAD MOST IMPROVEMENT IN WILLINGNESS TO CONSIDER A PEV AFTER TEST-DRIVE

An improvement of 18% for those not aware of any charging stations



- Almost a third of respondents were not aware of any charging stations but showed the most improvement in considering a PEV
- Respondents who have charging stations available at work and/or pass charging stations regularly while driving are the most likely to consider a PEV

Are you aware of EV charging stations along the routes you drive & places you visit in a typical day?



- Pass charging stations regularly while driving
- At your place of work
- At the stores and places you visit
- Not aware of any

*percent shown of each bar/column is the difference of 100 minus % of individuals not considering a PEV

CHARGING AVAILABILITY IS SIGNIFICANTLY CORRELATED WITH PEV ADOPTION

- Negative effects of **extreme temperature** were particularly strong for the total market and for the mass-market BEVs
- **State and federal monetized benefits** were twice as important for BEVs as for PHEVs
- **Level 2 public charging** availability shows significant positive impacts in the mass and total PHEV markets, but not in BEV markets.
- **Workplace charging** shows a positive but lower coefficient for BEVs than for PHEVs
- **PEV Readiness Grants** had consistent positive and generally significant impacts in all PHEV market segments, as well as mass-market and total BEVs
- **HOV lane subsidies** appear to be very important in the mass market
- **Income** has significantly positive impacts in EVERY market segment, dominating the education effect.
- **Fuel Cost:** Interestingly, gasoline prices are negatively correlated to the luxury BEVs, luxury PHEVs and mid-market PHEVs, but not mass-markets or total markets.
- Longer **Work Travel Time** significantly decreases luxury BEV and mid-market PHEV market adoption, but not mass markets.



Source: T. Bohn, Argonne National Laboratory

RESEARCH QUESTION – WHAT ARE THE EMISSIONS BENEFITS OF PUBLIC EVSE INSTALLATIONS?

- Who can benefit from this effort?
 - Numerous coordinators and other AFLEET users have requested support in estimating the emissions benefits of public EVSEs
 - Analyze the benefits for funding opportunities, e.g. VW



VS



AFLEET EVSE CALCULATIONS

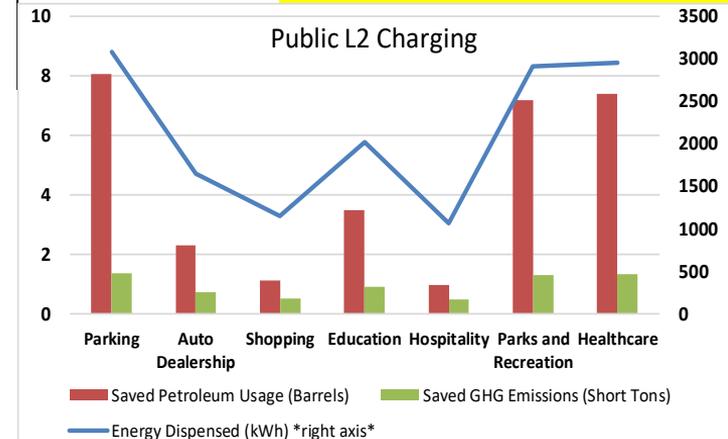
- Emissions benefit calculator of public EVSEs (AFLEET xls)
 - Analyzed charging data to provide defaults
 - Utilization by charger type
 - L2 vs DCFC
 - Utilization by charger location type
 - Public parking, auto dealership, shopping, education, hospitality, parks & rec, healthcare
 - Includes average session power and session charge time
 - Currently providing low, mid, and high estimates
 - In the future would like to tie them to EV market penetration in area
 - Further analysis needed to examine link between chargers and EV purchases

<https://greet.es.anl.gov/afleet>

Primary Vehicle Location	
State	ILLINOIS
County	COOK

Public Infrastructure Inputs

Level 2 Charging Infrastructure				
Predicted Weekly Utilization	Moderate			
County PEVs	6820			
County L2 Chargers	221			
Venue	Number of Chargers	Utilization (sessions/week)	Session Power (kW)	Charge Time (hours/session)
Parking	1	6	4.1	2.4
Auto Dealership	1	3.5	4.1	2.2
Shopping	1	3	4.1	1.8
Education	1	4.5	4.1	2.1



THANK YOU!

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